In re Patent Application of
BAHLENBERG ET AL.
Serial No. 09/529,427
Filed: NOVEMBER 1, 2000

REMARKS

Applicants thank the Examiner for the careful and thorough examination of the present application, and for the indication of allowable subject matter. A substitute specification in proper idiomatic English and in compliance with 37 CFR 1.52(a) and (b) is submitted herewith. No new matter is included therein. By this amendment, Claims 1-16 have been canceled and rewritten as new Claims 17-27 to eliminate the minor informalities pointed out by the Examiner, to be more consistent with U.S. practice, and to include the subject matter indicated as being allowable by the Examiner. Claims 17-27 are now pending in the application. Favorable reconsideration is respectfully requested.

In view of the amendments and foregoing remarks, it is respectfully submitted that the present application is in condition for allowance. An early notice thereof is earnestly solicited. If, after reviewing this Response, there are any remaining informalities which need to be resolved before the application can be passed to issue, the Examiner is invited and respectfully requested to contact the undersigned by telephone to resolve such informalities.

Respectfully submitted,

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MARKED-UP VERSION OF SPECIFICATION

TITLE OF THE INVENTION

Improvements in, or Relating to, Near-Echo Suppression

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to ~~a hybrid circuit for 2-wire to 4-wire conversion in which near-echo is substantially reduced for short lines and to a~~ duplex transmission system~~employing a plurality of said hybrids~~. and methods, and more particularly, to duplex transmission systems and methods including hybrid circuits to make

Discussion of the Background 4- wire to 2-wire conversions.

Hybrid balancing has been used for many years to make 4-wire to 2-wire conversions, and vice versa, for duplex systems using a single line. If the balance is less than ideal, a portion of the transmitted signal will leak through the hybrid into the received signal path. This is referred to as near-echo. If the near-echo is strong, compared to the received signal, more bits are required in an Analogue to Digital (A/D) convertor located in the receive path. The present invention relates to a technique for substantially suppressing near-echo before A/D conversion in 2-ware to 4-wire hybrid circuit.

A hybrid circuit, of the type to which the present invention relates, may be used with the invention described in our co-pending Swedish patent application Kgp 152/97, which relates to the application of the present invention to extending the reach of a VDSL.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a hybrid circuit having a balanced 2-wire to 4-wire hybrid for interconnecting a two wire receive path and a two wire transmit path to a two wire transmission line, ~~said~~ The two wire receive path ~~connecting~~ connects the balanced hybrid to an A/D convertor and ~~said~~ the two wire transmit path ~~connecting~~ connects a D/A convertor to ~~said~~ the balanced hybrid, ~~characterised in that said~~ The two wire receive path includes contains a filter. The hybrid circuit may be adapted to operate with a transmission system using orthogonal frequency divided duplex (OFDD) and the filter may be dimensioned to reject transmit signals originating from the D/A Convertor. ~~The said~~ hybrid circuit may be adapted to operate with a transmission system ~~employing~~ using orthogonal frequency divided duplex (OFDD), and ~~said~~ the filter may be dimensioned to reject transmit ~~signals~~ sub-carriers originating from ~~the said~~ the D/A convertor.

The ~~Said~~ hybrid circuit may be adapted to operate with a ~~transmission~~ duplex system ~~employing OFDD, and said filter may be dimensioned to reject transmit sub-carriers~~

~~originating from said D/A converter.~~

~~Said hybrid circuit may be adapted to operate with a duplex system having the following characteristics:~~

wherein all transmitters in ONUs and NTs in said duplex system are time synchronised;

(-) timing advance is calculated from line lengths;

(-) different sub-carriers are employed for up-stream and down-stream transmissions;

(-) a cyclic prefix is added to compensate for delay propagation in transmission lines; and

(-) frequencies above the FDD band are not employed for longer lines.

The ~~Said~~ cyclic prefix may be dimensioned for lines of length X ~~metres~~ and OFDD is used for lines shorter than X ~~metres.~~

The ~~Said~~ balanced hybrid and ~~said~~ the filter, together, may introduce a delay less than a delay for which said cyclic prefix is dimensioned.

According to a second aspect of the present invention, there is provided a duplex transmission system, ~~characterised in that said duplex transmission system includes~~ including a plurality of hybrid circuits ~~as described in any previous paragraph.~~

BRIEF DESCRIPTION OF THE DRAWINGS

~~Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:~~

Figure 1 is a diagram illustrating ~~illustrates, in~~ schematic ~~form,~~ a hybrid circuit according to the present invention.

The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

~~In order~~ To facilitate an understanding of the present invention a glossary of terms used in the description of the present invention is provided below:

A/D:	Analogue to Digital
ADC:	Analogue-to Digital Convertor
D/A:	Digital to Analogue
DAC:	Digital to Analogue Convertor
DMT:	Discrete Multi Tone
FDD:	Frequency Divided Duplex
NT:	Network Termination
OFDD:	Orthogonal Frequency Divided Duplex
ONU:	Optical Network Unit
VDSL:	Very high rate Digital Subscriber Line

Where an A/D convertor is located in the receive arm of a hybrid circuit, as illustrated in Figure 1, the number of bits required in the A/D convertor is determined from the input signal level. If the signal level is increased there will be a loss of resolution when the dynamic range is kept the same. If the near-echo is as strong as the received signal, the A/D convertor will require one extra bit to maintain the same resolution. For long lines, the received signal will be more attenuated than for shorter lines. The near-echo will not be affected by the line length. This means that longer lines will be more affected by the near-echo signal.

The present invention is particularly applicable to reducing near-echo signal

for the duplex scheme described in our co-pending patent application Kgp 152/97, and DMT symmetric transmission systems of the type described in our patent application PCT/SE 9600935. The basic concept presented in our co-pending application, ~~Kgp 152/97~~, is the use of Frequency Divided Duplex (FDD) for transmission at lower frequencies and Orthogonal Frequency Divided Duplex (OFDD), also known as Zipper, for transmission at higher frequencies. For long lines only, FDD is used for the lower frequencies (FDD). For short lines, an arbitrary up-/down-stream loading is possible for the higher frequencies. The key elements in the duplex scheme are:

- performance of time synchronisation between all transmitters in the ONU and the NTs;
- calculation of timing advance from the line length;
- use of different sub-carriers in up- and down-stream directions;
- addition of an extension of the cyclic prefix to compensate for delay propagation in the line - this extra cyclic prefix is dimensioned for X ~~metres~~, where X is the length of the shorter line; and
- not using the frequencies above the FDD band for lines longer than X metres, which means that FDD is used for longer lines and that OFDD can be used for lines less than X ~~m~~.

To suppress the near-echo signal before A/D conversion, a filter is inserted, see Figure 1. This filter removes the transmitted signal in the FDD band described in our co-pending application ~~Kgp 152/97~~, in which, where FDD is employed, different frequency bands are used for up- and down-stream bands. This ~~enables~~ allows filters to be used to separate up-stream bands from down-stream bands. For the ONU side, it will be the FDD downstream band that is filtered out and, for the NT side, it will be the FDD upstream band that is removed.

For long lines, where only the lower frequencies are used, i.e. FDD is

employed, there is almost no near-echo because of the filter. For shorter lines, where higher frequencies are used, near-echo will be reduced. Suppressing near-echo is more important for long lines where the received signal is more attenuated. To fulfil the orthogonality requirements, the delay of the hybrid plus the filter must be less than the delay for which the extra cyclic prefix ~~is~~ is dimensioned.

By using the present invention:

- the number of bits required in the A/D converter, when OFDD is used, is reduced; and
- for longer lines, near-echo is better suppressed.

~~For the avoidance of doubt the~~ The term OFDD, as used in this specification, is intended to embrace similar duplex techniques, such as those employing DMT, wavelet multiplexing, or the like.